

***Florida Reef Health from 2012 to 2017:
Major Indicators of Ocean Index Fluctuation***

An Honors Thesis (HONR 499)

by

Kami C. Kleefisch

Thesis Advisor

Dr. Joshua Gruver

**Ball State University
Muncie, Indiana**

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Abstract

Between 2012 and 2017, the health and resilience of the third largest barrier reef in the world, lining Florida's coastline, has deteriorated significantly. The Ocean Health Index (OHI) and the National Oceanic and Atmospheric Association (NOAA) have observed and communicated these trends. The United States OHI value for the previous six years has averaged 68 out of 100, ranking 109 of the 221 countries analyzed. Additionally, NOAA climate data suggests three sub-factors directly relating to oceans (temperature, ocean heat, and sea level) have been steadily rising each of the preceding six years. In order to capture how Florida residents perceive these threats to the reef, I traveled to southeastern Florida to interview community members on their experience with the reefs and what changes they have noticed in recent reef health. I chose to interview individuals with scuba diving backgrounds, as they have direct access to the ocean's environments and are familiar with regular fluctuations in populations, coral cover, and recreational behaviors. Interview results suggest in the context of recreation, while oceanic activities are valuable economically, uninformed participants can exercise behaviors that have a negative impact on marine life. Alternatively, in the context of climate change, interview results suggested that beyond bleaching events, natural disaster intensity has a detrimental effect on corals even if it stirs up lower temperatures in the water. To combat these challenges, stewards of Florida's reefs suggest to further educate the community and visitors on reef impacts of recreational activities and to participate in restoration efforts following a storm or bleaching event. To actively participate in this conversation, I invested in one of the efforts, community and visitor education, by developing a website where the results of my preliminary research and interviews surrounding Florida's reef health are outlined in a user-friendly interface.

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Process Analysis Statement

When I first started scuba diving nearly seven years ago, I was amazed and consumed by marine life. Then, when I traveled to the Florida Keys in 2013 with a team to conduct surveys for Reef Check, I quickly became committed to the health of the reefs. I recognized coral reefs as the foundation for many oceanic ecosystems and when I began investing in water quality through my undergraduate academics, I was drawn back to the waters I had once studied.

Before submitting my proposal for this project, I reached out to my first dive instructor, Dave Hall, to plant the idea of a trip back to the Keys, as he was one of my primary connections to the community there. Once he agreed, I dove into my preliminary research and began to plan for the journey. As a non-native to Florida, I knew that to provide sound observations and conclusions for an area where I did not permanently reside, I would have to visit the area and some of its community members to secure a well-rounded understanding of my topic. So in correlation, one major challenge in this venture was the duration of my stay. Once I had arrived, I had filled each day with interviews and commutes. Yet, often times during interviews I would be led in new directions without much time to pursue new leads or schedule new interviews. While a project of this scale could not encompass all the possible indicators of ocean index fluctuation, time certainly served as a restraint in obtaining further depth of the existing content.

When entering this project, I had expected that recreation and climate change would be two major causes of recent reef health changes and I was interested in reaching out to divers about these causes because of their direct relationship with the ocean. However, after talking with people of scuba diving backgrounds, I was made further aware of the magnitude and complexity of the problem. However, beyond the multi-sided effects of storms, climate, and tourism, I was

pleasantly surprised by the successful restoration efforts that were being conducted and maintained on Florida's reefs. In an environmental situation that is so massive in scale, successful systems should be recognized; these systems are what are restoring reefs from the ocean's current obstacles (eg. bleaching, vessel damage, diving recreation). Though there is a crisis for reef health in Florida, there are also passionate activists alongside it to lend a hand in its healing process. My written observations and supplemental webpage is a personal attempt to aid in and directly support this mission.

Introduction

Coral reefs, the rainforests of the sea, are the most diversely populated ecosystems on the Earth's surface, but their health is declining at significant rates; with business as usual, "by the 2030s, our estimates predict that more than 90 percent of the world's reefs will be threatened by human activities, warming, and acidification, with nearly 60 percent facing high, very high, or critical threat levels" (Burke, 2011, p. 45). Ocean and coral reef experts suggest that the pursuit of financial benefits and public interest in unique experiences (e.g. tourism and recreation) along with environmental factors (e.g. climate change) are major causes of global reef depreciation (NOAA, 2017a). With a concern for the loss of this major ecosystem and wanting to learn more about how people and communities understand and respond to their environment, I will be exploring southeastern Florida, the only portion of the continental United States coastline with extensive coral reef formations (Florida DEP, 2017). In doing so, I will focus on the recreational and climate change factors in the last six years that are contributing to its overall health decline.

I. Background

Coral reefs are the foundation for many oceanic habitats and have a unique development process. Minute polyps, organisms attached to the coral, secrete calcium carbonate and harden to form the outer shell of a coral; this cycle of polyp secretion is continuous and so can maintain the life of coral communities, or coral reefs, far beyond the lifespan of a single polyp (NOAA, 2017a). Many corals also contain zooxanthellae, which are microscopic algae that can produce products of photosynthesis from the coral's waste (NOAA, 2017a). However, since coral is an animal it does not rely on the process of photosynthesis to produce its own food as a plant would; instead, it captures its own food through tentacle extremities and releases the oxygen and organic

products from photosynthesis back into the environment as a support for reef growth and habitat health (NOAA, 2017a). Off the east coast of Florida and into the Florida Keys, Staghorn (*Acropora cervicornis*) and Elkhorn (*Acropora palmata*) are the two foundational hard corals for reef development and growth (CRF, 2018a). The population of these species is growing sparse; approximately 90% of Elkhorn corals have been lost in the last four decades (CRF, 2018a). Yet, many economic opportunities are tied to the reefs and the resources they provide. In monetary terms, an estimated value of Florida's reefs is 30 billion U.S. dollars (Lane, et al., 2013). Since this value is reliant on coral availability, it is concerning that by 2050, it is expected that 25% of all coral reefs will be exposed to medium threats, while the remaining 75% will be exposed to critical threat levels (Burke, 2011). These medium and critical threats refer to a business as usual approach in both behavior and continued greenhouse gas release scenarios. Corals are the backbone of reef ecosystems and by isolating and evaluating the causes for their depreciation, effective solutions can be identified and executed.

Reef tourism evolved out of growing opportunities within oceanic recreation. Marine exploration began around the early 1800s with the British HMS Challenger as the first expedition along the seafloor of the Atlantic, Indian, and Pacific Oceans (NOAA, 2017c). At that time, it was the Americas, Britain, and Europe whose people expressed curiosity about ocean currents, ocean life, and the vastness of the seafloor. This human interest in the ocean's capacity and contents continue to entice the imaginations and curiosity of many, especially where expeditions are now no longer the only means of exploration. An alternative, scuba diving, emerged as a possibility in the early to mid-1900s when Germans, Jacques-Yves Cousteau and Émile Gagnan, developed a safe and reliable open circuit underwater breathing device, Aqua-Lung (MIT, n.d.). This patented

device is still the foundation for the equipment divers use today to explore the depths of the oceans. It has aided in the pursuit of financial benefits and public interest from which oceanic recreation and tourism have grown, but neither is without its risk to the reefs.

Significant climate change, however, has been ongoing since the 1880s, at approximately the time of the Industrial Age. The temperature of ocean surface water has been rising steadily for over twenty-five years, just as the Earth's surface has been for over forty-five years (NOAA, 2018c). While these annual, fraction of a degree changes may not seem significant, even small deviations in an ideal environment can introduce stress on corals because they are extremely sensitive to temperature, light, and nutrient fluctuation. As their environment heats up, many corals contract a condition known as "bleaching", which occurs when a coral is stressed from increased temperature and its zooxanthellae algae leave, causing the coral to turn white (NOAA, 2017b). This process does not necessarily kill the coral, but routine exposure to similar conditions dramatically increases the likelihood of its mortality (Florida Keys NMS, 2011). Yet, should a coral survive the bleaching incident, it cannot support reliant ecosystems while it is enduring the process. In addition to bleaching, ocean acidification is another detrimental effect of climate change on marine ecosystems. Acidification, however, does not occur from temperature increases, but from increased concentrations of carbon dioxide that are released into the air and absorbed by the oceans. This absorption then alters the water's natural pH, making it more neutral than acidic and affects organisms' ability to produce and maintain shells, which inherently stifles a prey's ability to protect itself in the marine food chain (NOAA, 2018d). Incidents of coral bleaching and ocean acidification are two considerable results of climate change on ocean life, as they both compromise the structural foundation of the reefs.

Florida contains the only portion of the continental United State's coastline with extensive coral reef formations; this barrier reef extends 350 miles from the St. Lucie Inlet in Martin County to the Dry Tortugas in the Gulf of Mexico and is largely protected by the Florida Keys National Marine Sanctuary (see Figure 1). It is the third largest barrier reef in the world and so attracts millions of vacationers each year for its beauty and ecological diversity. Yet, as recreation in the area continues to generate a reliable revenue source for coastal communities, it simultaneously invites negative consequences from unfamiliar or uninformed visitors (NOAA, 2017b). Similarly, as climate change is present, temperature and pH fluctuation will continue to inhibit the lives of healthy corals. These anthropogenic behaviors (e.g. recreation through tourism and public interest) and environmental factors (e.g. coral stressors through climate change) are having detrimental effects on coral reefs, specifically along Florida's coast. I will observe these effects by collecting information from communities with similar scenarios or concerns and talk with locals who have experienced the changes directly.

Figure 1: Florida Reef from St. Lucie Inlet to the Dry Tortugas



Source: US Department of Commerce, National Oceanic and Atmospheric Administration (2009, June 29). NOAA CoRIS – Regional Portal – Florida. Retrieved December 10, 2017, from <http://www.coris.noaa.gov>

Literature Review

As the health, quality, and cover of Florida's reefs continue to decline on an annual basis, this literary review will consider specifically how recreation and climate change have contributed to this concern since 2012. To establish a framework for these two categories I will rely on the data published by Ocean Health Index and the National Oceanic and Atmospheric Administration for recreation and climate change respectively. For the recreational factor, I will use sources from national and global reef services to explore similar ecosystems, the core effects of recreational activities, and what has been done to restore or protect areas that have been affected. For the climate change factor, I will use sources that analyze climate fluctuation in southeastern Florida, how it has affected the residing reefs, and what can be expected for the reef population should business continue as usual. This section will be broken into two main causal sections: recreation and climate change, each with an identifiable sub-section for units of measure, followed by supporting texts relevant to the respective concerns of the main sections.

I. Cause: Recreation

People tend to flock to locations with natural beauty; others prepare for their arrival by translating potential interest into profitable revenue. The state of Florida is desirable for its comfortable temperatures, variety of resources, and breathtaking views; the surrounding barrier reef welcomes a multitude of native hard and soft corals, invertebrates, and fish that visitors travel to the region to see, taste, and interact with. Beyond the mainland, Key West alone accounted for over one million of the state's international visitors in 2016 (Key West Travel Guide, 2018). Unfortunately, it is a combination of a detached sense of place and lack of education about environmental needs that is resulting in disruption of the local marine

ecosystems. By determining a reference unit of measure and collecting comparable recreation-to-reef scenarios, expected projections, and preservation opportunities, disruption of these ecosystems can be minimized.

Unit of Measure: Ocean Health Index

To consider the impacts of recreation and tourism on an ecosystem, the Ocean Health Index (OHI) was developed as an assessment tool in 2012 to rank coral reefs of a given location according to several sustainability factors (OHI, 2017b). Factors include: Food Provision, Artisanal Fishing Opportunities, Natural Products, Carbon Storage, Coastal Protection, Tourism & Recreation, Coastal Livelihoods & Economies, Sense of Place, and Clean Waters and Biodiversity. When determining the OHI score, each factor is assigned a value that articulates what the current resource's capacity is without having to sacrifice its future capacity to provide the same quality. If an area is noted as sustainable following a category analysis, then it will receive a high score (up to 100), but if a category is not noted as sustainable in that area then it will receive a lower score. By these parameters, a combination of these factors is averaged to assign a value to a location in the form of its overall OHI score. By the trends of this overall score, the United States has maintained or declined in this unit of measure over the last six years, staying within the high 60s and low 70s, but without increasing (OHI, 2017a). Most recently in 2017, the U.S. ranked 109 of 221 countries and territories represented (OHI, 2017a).

Opposing Coastlines

More specifically, the OHI+ Portal is a collection of in-depth coastline assessments that provide the breakdown of an Ocean Health Index score for a specific location (OHI, 2018b). For the

United States, a West Coast OHI+ assessment was completed in 2014. To predict the potential impact of factors on the southeastern coast that encompasses Florida's reefs, I used the U.S. West Coast case study as a comparable example. In this case study, individual factor scores were listed in addition to the compilation score. In the factor breakdown, recreation was listed as one of the factors with the highest score, 99, this means that recreation on the U.S. West Coast is providing an exemplary set of resources and experiences to tourists that can be equally upheld for the foreseeable future (OHI, 2018b). Likely, recreation in this context is being used to refer to the satisfaction of the visitors more so than the potential effects such recreational activities are having on the environment. This is because factors that link to the environmental effects of recreation, such as coastal protection, 58, and biodiversity, 69, received some of the lowest scores for individual assessment factors (OHI, 2018b). Additionally, habitat goals for these two lowest factors have declined between 5% and 20% over the last decade (Halpern, et al., 2014). Recreation represents more of the attraction to the area and influx of annual tourists, which is notably high, in comparison to the sustainability of other factors such as the protection of diverse habitats, which is significantly low. This case study is not a mirrored example of the southeastern coast; just as the U.S. West Coast does not have coral reef formations along its coast or a National Marine Sanctuary, so a OHI+ assessment of Florida's reefs would vary in these respects and likely others, however, it is a fair introduction to understanding the compartmentalization of the individual factor scores and how they connect.

Recreational Activity Types

Effects of recreation on a reef vary in scale and concentration. Reef Resilience, a partner with NOAA and Florida Keys National Marine Sanctuary, speaks well to the kinds of harm

recreational activities can have on reefs. Recreational harm to coral can be categorized into three main types: harm to coral through direct contact or boat and anchor disruption, harm to other marine life from human interaction, and harm to the environmental quality from direct and indirect pollution or invasive species introductions (The Nature Conservancy, 2018). Expanding on these categories, Reef Resilience explains what these terms mean in the context of recreational use and activities.

Direct contact is when a diver or snorkeler grabs, touches, kneels on, stands on, or accidentally swims into coral (The Nature Conservancy, 2018). These types of actions leave the coral with lower reproductive and regenerative potential. Anchors have a similar effect when dropped on corals, separating and damaging their ability to prosper; they also can harm nearby sea grasses that serve as the nursery grounds for many new corals to form (The Nature Conservancy, 2018). Thankfully, the implementation of more mooring buoys, which are essentially floating anchors that boats can hook onto so they do not drop a traditional anchor on the seafloor, has certainly slowed these incidents. Beyond anchor damage, vessel groundings are the more drastic collision between vessels and reefs. When a vessel grounds it can grind on a reef for thousands of square miles (The Nature Conservancy, 2018). So, the Florida Keys National Marine Sanctuary has established boundaries for vessel traffic along the state's shoreline to avoid these types of incidents (Florida Keys NMS, 2011).

Changing behavior is another consequence that recreation can have on organisms. As people continue to experience wholesome interactions with species, public curiosity and interest grows. More people flock to areas where popular creatures can be spotted such as seahorses, sharks,

whales, dolphins, or barracuda, assuming there have been minimal reported injuries. Those who see an educational or financial opportunity may introduce 'feedings' to keep animals in an area despite increased traffic. Feeding can cause fish to spend less time obtaining food, decrease their home range, affect their reproduction and migration, and has the possibility to increase their aggression toward people (The Nature Conservatory, 2018). When I observed a nurse shark feed in March of 2018, I could see why some of these points may be a growing concern. Before the feed began, a nurse shark had already approached and began to circle me. This simple act, though no aggression was shown, does support the intelligence of these animals and how they associate divers with the feeding that was soon to come. Being aware of how human actions can alter animal habits is integral in learning where human boundaries must be in the oceanic world.

Another consequence of recreation on the reefs is the opportunity for pollutants to enter the water. Plastic waste is a large concern for the ocean because people visiting an area may not be thinking about the implications of plastics on marine life (The Nature Conservatory, 2018). One example of how plastics can harm an ecosystem is when they float in a sea turtle's path. A sea turtle's primary food source is jellyfish and when a plastic bag or wrap is floating in the water it can be easily mistaken for a typical treat. This mistake then disrupts the animal's digestive track. In addition to mistaken food sources, invasive species are an immensely harmful disruption in a marine habitat food chain (The Nature Conservatory, 2018). A common invasive species in the Florida Keys is the Lionfish and like many similar species, shares few predators. So, as the population of the Lionfish exponentially increases, the habitat is stripped of marine diversity. Together, these harmful consequences from recreational activities (e.g. contact or boat and

anchor disruption, human interaction, and pollution or invasive species introductions,) are a substantial piece to understanding the reefs' declining health.

Potential Management Technique

In 2010, the State of Hawai'i Department of Land and Natural Resources Division of Aquatic Resources partnered with local coral programs to develop the Hawai'i Coral Reef Strategy (NOAA, 2010b). This strategy focuses on four key goals: protection for undamaged reefs, sustainable habitats, resilient ecosystems, and public stewardship (NOAA, 2010b). In pursuit of investing in these topics, the Hawai'i Coral Reef Strategy (HCRS) addresses recreational overuse as a primary need for management. This strategy focuses on snorkeling, diving, and boating specifically in terms of coral skeleton and tissue breakage, changing marine behavior, and water pollution (NOAA, 2010b). A reason why the HCRS views recreational overuse as a priority in resource management is the unignorable concentration of the state's annual population of tourists; as 50% of these annual tourists either dive or snorkel on their stay, the potential for direct contact and coral exposure dramatically increases where tourists are present (NOAA, 2010b). This is also a considerable factor when the HCRS context recognizes a majority of recreational effects occurring on shorelines where people tend to congregate.

In Hawai'i's Ten Year Priority Objectives for Reef Management (spanning from 2010 to 2020), the HCRS identifies five main objectives that encompass a combination of its four key goals. The first is the most thorough and aims to reduce anthropogenic threats in two shoreline areas in the first five years; these are Ka'anapali-Kahekili and Pelekane Bay-Puako-Anaeho'omalua Bay. There is also a plan for five additional sites in the following five years, but for Ka'anapali-

Kahekili and Pelekane Bay-Puako-Anaeho'omalū Bay, anthropogenic threats were reduced by identifying needs of area through data collection, development of teams and sub-committees for focused concentration on topics, change and projection monitoring, stewardship encouragement, and result analysis (NOAA, 2010b). These actions led the two areas to receive further precautionary measures for recreational users. These measures included: hired enforcement for resource restrictions and licenses, community education, and pollution reduction strategies to promote species diversity and coral reproduction (NOAA, 2010b).

The remaining three key goals are more indirectly correlated to human impact than the first. The second key goal focuses on minimizing Aquatic Invasive Species (AIS) through prioritizing species concern, identifying prevention techniques, and determining potential eradication processes (NOAA, 2010b). The third and fourth key goals focus on widening the density and size of fishery populations and denoting specific marine waters to strict conservation (NOAA, 2010b). While the first goal in the HCRS is directly related to lowering human impact on the reefs, the second, third, and fourth goals focus on restoring where there has already been negative human impact. Just as invasive species populations can be caused from human introduction, weakened species diversity can be caused by human interaction also. Since human impact can be found woven in each of the HCRS key goals conservation is needed where reefs are too sensitive to naturally heal or are too valuable to disappear.

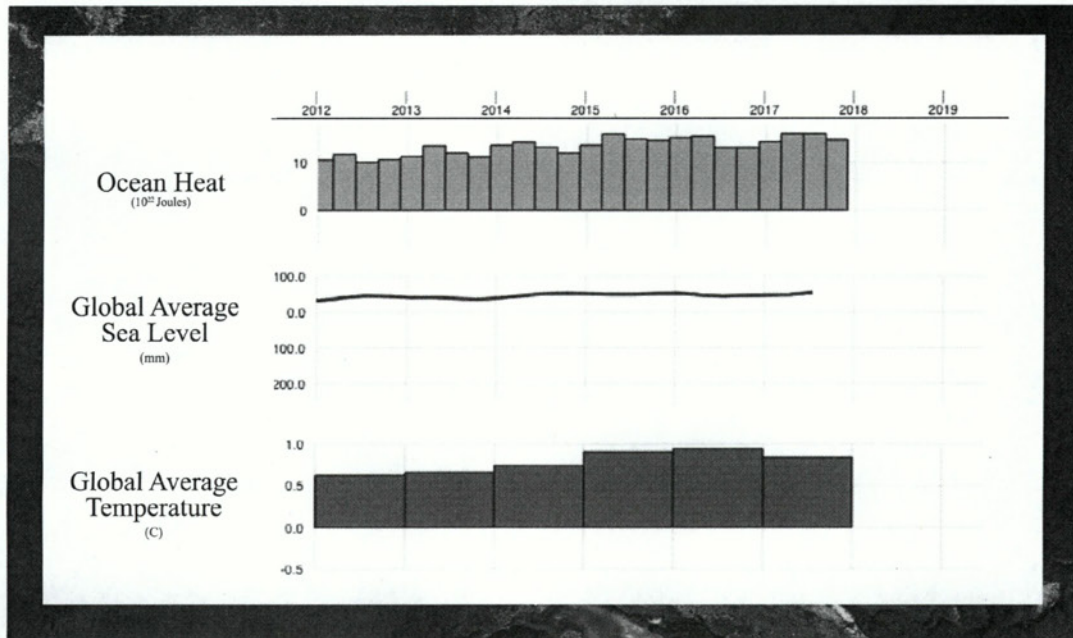
II. Cause: Climate Change

Just as rising temperatures within the Earth's atmosphere increase a few tenths of a degree each year, similar increases have been occurring in surface sea temperatures over the last four decades (NOAA, 2018c). Temperature increases in the ocean contribute to coral sensitivity events and forced organism adaptations. While these changes may seem marginal, they are leaps ahead of projections and the effects are already grabbing global attention. By determining a reference unit of measure to identify the ocean's current state, effects from changes, and expected projections, the knowledge of how humans fit into this larger natural process can be maximized.

Unit of Measure: NOAA Climate

The National Oceanic and Atmospheric Administration (NOAA) provides annual climate change data as it relates to eight main topics: Global Average Temperature, Global Average Sea Level, Sun's Energy, Carbon Dioxide, Arctic Sea Ice, Glaciers, Snow, Ocean Heat, and Heat-Trapping Gases (NOAA, 2018c). Of these, three topics that seem to have a strong tie to coral reefs are Global Average Temperature, Ocean Heat, and Global Average Sea Level (see Figure 2). Each of these three have been on a similar, proportional trajectory from 2012 to 2016 (NOAA, 2018c). In 2016, both Ocean Heat and Global Average Sea Level dipped, but Global Average Temperature increased. In 2017, the opposite happened; Ocean Heat and Global Average Sea Level increased, but Global Average Temperature decreased. Even while these trends certainly have some variability, their overall trajectory increase is undeniable.

Figure 2: NOAA Climate for Ocean Heat, Sea Level, Global Temperature



Source: NOAA. (2018, April 19). NOAA Climate.gov | science & information for a climate-smart nation. Retrieved April 2, 2018, from <https://www.climate.gov/>

Large Scale View of Depletion

As Florida's coast is home to the third largest barrier reef in the world, its challenges with maintaining reef cover and health are not a rarity; the largest barrier reef off the northeastern coast of Australia, the Great Barrier Reef, includes 130,000 square miles of reef that has faced these challenges for decades. From 1985 to 2012, the surface area cover of the Great Barrier Reef has depleted by over half (De'ath, 2012). Some of the concerns attached to this tremendous loss of reef cover were attributed to rising seawater temperatures, ocean acidification, water pollution, and coastal development; a combination of all these sensitive changes led to increased mortality and reduced growth in the marine ecosystem. This dramatic loss of coral surface area stems from tropical storm destruction because as surface water temperature increases, the intensity for cyclone type storms also increase (De'ath, 2012). These storms tear through coral

formations and habitats for miles, displacing species and the devastation is far greater than the preceding years of temperature changes.

De'ath's twenty-seven year study of the Great Barrier Reef calculated the impact of bleaching, however, to be the cause of only 10% of total coral mortality. Instead, De'ath, concluded aside from increased temperature and tropical storms, predatory starfish were the second most contributing factor to the reefs overall health decline (2012). This type of starfish, crown-of-thorns, has been active in depleting the coral population almost every year since 1985. This predator was an environmental constant and in combination with bleaching and tropical storm incidents, is responsible for a 3.38 percent increase in annual coral mortality. Yet, this has been a active trend on the reef for so long that even in the theoretical absence of these three indicators (e.g. storms, bleaching, and starfish population) now, the coral cover would only return at an annual rate of 2.85 percent, so never fully restoring to its original populations and quality (De'ath, 2012). Even as a hypothetical and ideal scenario, the reef is depleting beyond repair. While there are measures available to prevent further health decline and cover in coral habitats, they will only be successful if and when climate conditions are stabilized (De'ath, 2012). If greenhouse gases continue to be collected into the atmosphere, the cycle of temperature increase, tropical storms, and weakened sensitivity to predators, coral depletion will continue indefinitely.

Centennial Look at Oceanic Climate Change

The impact of climate change on reefs in the United States region since 2000 can be used to project expectations for potential impacts on United States coral reef regions in the next one hundred years considering a Business As Usual (BAU) approach (Lane, et al., 2013). While a

century-long analysis is broad in timeliness, a U.S. coastline extracted from global scrutiny is a valuable observation when identifying trends. One effect of climate change that Lane explores is the increased carbon dioxide concentrations within marine habitats from greenhouse gases (GHG); she claims that the reefs of Florida are so close to their cleaning thresholds that there is little to be done to protect their economic benefits (Lane, et al., 2013). These thresholds can be understood as the point to which coral can recuperate after a sensitive event. One example is when multiple bleaching events occur within consecutive years. As GHG promote surface sea temperatures to rise, corals experience more frequent bleaching incidents and this type of reoccurring stress does not allow the corals enough time to recover naturally. It is other places in the U.S. like Hawaii that have a greater chance of avoiding future bleaching events and salvaging economic benefits because emissions have not yet risen the sea temperature to an intolerable value, but this too is on a pending timeline. As one could guess, a great deal of motivation to protect these reefs from their one hundred year BAU projections is for financial gain. The communities surrounding Florida's coastlines are well aware of how the habitat of the reef provides them with financial opportunities, rather it be for recreation activities or selling collected resources. While it may be restricting to pursue environmental restoration or maintenance for this purpose only, it is a start in broadening conversations about climate change effects on the reefs.

Methods

To further understand the perceptions of reef health on the Florida coastline, between the St. Lucie Inlet and the Dry Tortugas, as it compares or correlates with what previous studies have observed, I chose to talk with active locals who have a passion for ocean health and restoration. These locals included individuals of scuba diving backgrounds or that work with organizations of a restoration focus. To do this I stayed in Jupiter, Florida and traveled to meet each of them between Monday, March 5 and Wednesday, March 7, 2018 (see Figure 3).

Figure 3: Travel from Jupiter to Key West



For this three-day period, I scheduled six interviews prior to my arrival, spanning the 247 miles between Jupiter and Key West. I planned to conduct 20-30 minute in-person interviews that aligned with the following core ideas: perception of reef health, coral reef contributions to community, local attitude towards the reefs, where information is being obtained regarding coral reefs, and potential improvement recommendations.

I. Itinerary

On Monday I was scheduled to meet for three interviews. The first two, with Frazier Nivens and Spencer Slate, were located in Key Largo and Tavernier Key respectively. They both lasted between twenty and thirty-five minutes and occurred consecutively before noon. Both Nivens and Slate in their interviews referenced the Coral Restoration Foundation and the work they were doing with coral nurseries and outplanting. When I learned my third interview of the day had to cancel, I stopped by and talked with a representative from the foundation for approximately a half hour. The two of us were able to share a conversation about the foundation's mission, progress, and goals before I had to travel to Key West for an interview the following morning.

The Coral Restoration Foundation (CRF) is an organization that restores the damage of coral reef by growing new corals in nurseries and outplanting them in new locations. This process begins with a Coral Tree Nursery™ that the organization developed in 2010. This invention suspends coral fragments on branched out PVC pipe using monofilament line (CRF, 2018b). The framework is regularly cleaned and since it hangs suspended between the surface and ocean floor with the use of buoys the coral have a flexible environment to regrow in, as opposed to being secured to the seafloor. Using this method, CRF grows large quantities of Staghorn and Elkhorn, as both are integral and foundational corals to Florida's reefs and have been diminishing in population from bleaching and other natural disaster related incidents (CRF, 2018a).

On Tuesday, I was scheduled for two interviews between Key Largo and Riviera Beach. In the morning I met with Mike Buchman of NOAA for just over twenty-five minutes before leading me over to the adjacent building, Florida Keys Eco-Discovery Center to explore. There we

observed some of the grown corals on display and viewed comparison images of the reefs over decades. Then I drove back the 239 miles north for my interview with Jeff Nelson later that afternoon at the dive shop where he works, Force-E Scuba Center.

NOAA is the overarching agency in the U.S. Department of Commerce that oversees these organizations and many others for the sake of understanding and predicting oceanic conditions (NOAA, 2018a). To do this, NOAA has over 18,000 professional personnel working to further knowledge, study, or monitor the Earth's environments by compartmentalizing their efforts into nine key focus areas; Climate, Oceans & Coasts, and Sanctuaries are three that more directly affect oceans. Under the blanket of Oceans & Coasts, NOAA has supplied a grant to the CRF in Key Largo for their continued success with coral replanting.

Wednesday I had scheduled two morning dives in Tavernier Key and my final interview. I left for the dives by boat at 9a; the first was a reef dive and the second was a shark feeding. I returned from both around 1p and left for my afternoon interview with Lauri Maclaughlin at 95.2-mile marker. There the two of us shared a casual conversation about NOAA and the National Marine Sanctuary for over two and a half hours. We did not have time for a formal interview to follow at that time, but discussed a tremendous amount about NOAA's mission and recent actions for conserving marine health.

Under NOAA's Sanctuary key focus area, the agency has directly administered the Florida Keys National Marine Sanctuary in Key Largo for the last twenty-seven years (Florida Keys NMS, 2011). This Sanctuary is one of fifteen and protects and monitors over 2,800 miles of water,

encompassing the southern half of the mainland state's coast from Miami to surrounding all of the Keys through the Dry Tortugas. Some ways that the Sanctuary helps to protect these areas are by assembling mooring buoys for boats to hook up to and avoid anchors being dropped on corals, sectioning off vulnerable areas from fishing or recreation, and limiting the distance between ships and the shore so they don't run aground. The boundaries of the sanctuary help to determine sensitive portions of the reefs and limit their exposure to potentially avoidable interactions. It has been through a combination of observations, research, active restoration, offered education, and financial support from groups like NOAA, CRF, and the Florida Keys National Marine Sanctuary are working to improve the health of Florida's reefs.

II. Analysis

Interviews were digitally and audio recorded. The responses were then combed through to identify similar themes in participants' responses. These themes were then assigned to broader topics of either recreation or climate change. This way, I was able to compare my findings more easily with my preliminary research, also organized broadly by recreation and climate change. Immersing myself in local perspectives gave me a better sense of community changes, shifting population dynamics, and site transformations that have impacted the health of these reefs, but may have been unaccounted for through raw statistical data collection. The responses I gained in my interviews also revealed priorities for protection and restoration efforts on the reef.

Findings

In these conversations, I gained a greater insight into the factors that plague Florida's Reef system and what is being done to combat them. For clarity, this findings section is separated into profiles to describe the types of individuals I interviewed and themes to decipher common trends between my conversations with each.

I. Profiles

Many of the participants I shared a conversation with are professional scuba divers or activists who supplement their studies and experience in the field as a diver. A diver's perspective on reef health is anthropologically valuable because they work with the reefs directly, sometimes visiting the same ecosystems multiple times a day and can recognize its changes. In addition to this, divers are naturally integrated into relationship with various other recreational users, such as fisherman or boaters. These cohesive relationships that form between community members, who also rely on the ocean's resources, have developed out of care, necessity, and understanding. Scuba divers are only one component of the many who participate in ocean recreation, but they also have undisrupted, regularly connected ties to the reefs. It has been through a combination of personal observation and relationship building that scuba divers have significant insight into the status of Florida's reef health and so I chose to interview the following four individuals.

Multi-Emmy winning Underwater Cinematographer, Frazier Nivens, has observed marine life all over the world through a wide-angle lens. He is currently living and working in Key Largo.

Inducted into the International Scuba Diving Hall of Fame in 2004, Captain Spenser Slate has been running a dive and snorkel operation in the Keys for forty years.

Immensely knowledgeable Michael (Mike) Buchman is the chief of staff at NOAA; he has also been acting as the team leader and a NOAA diver for the science team.

Passionate diver, Jeff Nelson started in the scuba industry twenty years ago as a boat guide. Today he is an instructor at Force-E Dive Shop in Riviera Beach.

II. Themes

To organize the interviewing content gained from the participating individuals, I observed topic trends between the participants' responses and separated them into themes of stewardship, restoration, recreation, economy, tropical storms, and ocean warming. Together, these categories were further filtered into broad topics of recreation and climate change, where recreation includes stewardship, tourism, and economy, and where climate change includes ocean warming and tropical storms. Following the focused interview questions, participants also had the opportunity to offer potential solutions to reef health challenges and are included in the final section, restoration.

i. Recreation

This section includes excerpts from my conversations with Frazier Nivens, Jeff Nelson, Spenser Slate, and Mike Buchman that expose the stewardship, tourism, and economic strands in the recreational effects on Florida's marine life.

Stewardship

“Everything has to have respect” (Nelson, 2018).

Nelson acknowledges the delicate balance between the ocean's resources and human behavior. Where a person may be inclined to touch something on the reef or take something from it, those actions can have tremendous repercussion on the ecosystem. When people interfere with marine life, the habits of those marine species can change. Learning to respect marine life is first learning more about it. Education has the ability to alleviate disproportionate fears or spark further interest. By investing in the knowledge of marine systems and their importance to life's continuum, harmful behaviors affecting the ocean's resources can be calmed. Being a steward of the ocean is taking these actions rooted in respect and combining them with a genuine care for marine life and water quality. For Nivens, the lack of these actions is most notably seen in trash disregard. Especially when in close proximity to the water, trash disregard on beaches and in surrounding parking spaces can be swept up into the ocean's waves from the wind or rising tides. Nivens speaks to his own concern, “It troubles me greatly we are not being better stewards of our oceans” (2018). When divers, fisherman, or boaters go out they also need to be cognizant on where their trash is. Just as empty containers or bags can quickly fly overboard, instances like this can accumulate if recreationalists are not aware of where their trash is or are not keeping it secure until a trash or recycle bin is located. Nivens claims we can become better stewards of our oceans simply by being more aware of our trash disposal (2018). Slate also speaks to this profile of stewardship through his relationship with lobster fisherman. He describes, “the moral obligations of divers is to actively invest in the health of the reefs by removing or moving foreign objects that disrupt the marine habitats” (Slate, 2018). One of the ways he does this is by

removing lobster traps off the reef that storms have washed up. Since the lobster fisherman may have hundreds of traps, often times they do not know which ones may have affected the integrity of a reef section (Slate, 2018). Similarly, divers collect trash that they find on dives and bring it to the surface where it can be processed separately, without bringing further damage to marine life. Unfortunately, occasional trash pick up on dives, is not the only obligation for community members in the context of ocean pollution.

Tourism

“When they [visitors] come out to sea they don’t know better - they see live coral, they see pretty fish, and to them it’s marvelous - it has all the value as if it had been as healthy as it was decades ago” (Buchman, 2018).

When people travel to the Keys, they have no way of knowing the reef health is changing because they have no frame of reference. Even though reef health is declining, it does not mean that beautiful, healthy reefs are nowhere to be found. Instead, they are smaller and more sparse. Even so, Buchman explains, “The Florida Keys and the National Marine Sanctuary here is unique in that it is the only coral reef that any American can drive to.” (2018). Visitors flock to the area for the resources and experiences, but even more so for the accessibility. When a visitor has no frame of reference it can be difficult for them to understand why protecting the reefs is so important, because they are still available. Nelson responds to this potential question,

“People may say, ‘What if a little bit of reef goes away?’ Well that little bit of reef may be feeding an animal that lives or comes here for migration. If we take away a habitat that

they are spawning in or using as a food source and it gets killed off then they won't come by here anymore. You lose that tourism because that is what people are coming to see: a unique, natural phenomenon" (2018).

While there are still reef ecosystems present in our oceans, by continually altering the landscape through harmful behaviors or lack of preventative action, more species will continue to disappear until marine ecosystems collapse. An alternative to this is when a species may stay in the area but their behavior changes. Nelson passionately considers questions that surround human interaction as it can affect animal behavior, "Have numbers changed because we're diving them too much?" "Are they going somewhere else because they are being bothered?" "Have they moved over to this area where there is feeding going on?" (2018). However, while human interaction can certainly disrupt natural processes, the extent of which is difficult to calculate.

Slate may be able to give us a good place to start. He estimates, "There's over a million divers and snorkelers that come to the reef each year, in the Keys" (2018). Considering the likelihood that many of these divers (and snorkelers) will go on more than one dive during their stay, the number of contact points per year on the reef begins to soar well over a million. These million unique travel plans and itineraries are introducing more boaters, more divers, and more fishermen sharing resources, time, and space with an already fluid, local community. Certainly, this influx in population density to an area can also affect natural habitats if it is not effectively monitored or planned for. One way that Slate decided to tackle this issue was through the development of artificial reefs on the state's coastline. Slate partnered with the Artificial Reef System to install seven new sites. The first, Spiegel Grove, was an immediate attraction; he

recalled, “There were 70,000 dives done on that wreck in a year. So, we’re taking 70,000 (50,00 or even 40,000) dives off a natural reef a year” (Slate, 2018). Artificial reefs serve as a “reef buffer” to the potentially high concentrations of people visiting a natural reef. It also can be used as a solid education tool, where diving students can learn on it without the danger of damaging a natural reef from direct contact. Artificial reefs are something locals and visitors can both enjoy and visit without a minimized worry of negative environmental impacts. Even so, many people enjoy the natural resources of the Keys, especially the people that live there permanently. Nivens acknowledges, “A lot of people that live in the Keys love the ocean, of course, because it is part of their lives; people have boats, they go out and enjoy the reefs, they enjoy the lobsters, they enjoy going out to fish” (2018). When considering the impacts of recreation on a marine environment, local behaviors need to be monitored alongside visiting behaviors too, because both are direct outlets to the ocean.

Economy

“Billions of dollars in the economy are based on the Florida reef track” (Buchman, 2018).

The reef is a fluid investment, but the economy is not only reliant on the reefs because of its potential for acquiring vast revenue, it also is for the job security of the local community. People are working alongside the reef’s resources and the goods or services it provides both because they have the opportunity and because they need to. Buchman elaborates on this point further by using his present location as an example,

“There’s no doubt that the Florida reef track is the lifeblood of Monroe County, it is the economic engine that drives this county; about 70% of the jobs are either directly or indirectly related to the reef track” (2018).

Where tourism can often be seen as a negative factor to a location when considering environmental impacts or increased population density, from an economic perspective tourism can have immensely positive impacts. Slate recalled, “The Tourist Development Council [TDC] considers one dollar that you come down here and spend as a visitor to the Keys rolls over five times” (2018). This means that as one dollar is spent at a local shop, the dollar then is used to pay the employees who work there; then the dollar is used by the employees to buy supplies or food; another business gains the dollar and they pay their employees; so the cycle continues. This uses a once foreign dollar and integrates it into the local economy. Tourists also invest in this cycle through real estate. While storms or climate may affect the quality of some residential structures, Buchman explains that the availability of these sites are what make them valuable, “As far as sales, if the home survives [a natural disaster] value is increased; in the rental market there is so much less available now - supply and demand - so people are getting top dollar” (2018). The cycle of supply and demand is what can keep tourism alive even when the area has endured a recent obstacle. There is still beauty to witness in these areas, with minimal availability, so the consumer is willing to pay more to have access. Yet, these benefits of tourism in the economy are not met without stress on the environment. Nelson speaks to this when he considered a specific species of shark a few years ago, “When we had the lemon sharks migrating, they [divers] were diving the site all the time every day, two times a day, even on the weekdays because it was popular and they were making money” (2018). Though there are economic

benefits to increased tourism from a unique site or experience, it also strains the capacity of these ecosystems when they are over encountered for a short period of time. In order to avoid over exposure, there must be an awareness and balance in resource use or all benefits disappear when the ecosystem is lost.

ii. Climate Change

This section includes excerpts from my conversations with Frazier Nivens, Spenser Slate, and Mike Buchman that expose the ocean warming and tropical storm intensity effects on Florida's marine life through climate change.

Warming

“Even with a natural phenomenon like a hurricane, our fingerprints are all over that; because of global warming these events are much stronger and the damage they’re causing is much greater” (Buchman, 2018).

Warming of the Earth's surface and the oceans does not only create challenges, it also can increase existing conditions' frequency or intensity. Where increased temperatures are reflected in recent storms, they are also what can increase the frequency of bleaching events and to what extent they consume reefs. Buchman observes, “In a system that is already stressed, we're not sure if they [corals] are able to rebound” (2018). Since corals are enduring both bleaching events and storm events, sometimes they do not have enough time of favorable conditions to regrow on their own. Instead, they are dying quicker and in larger collections. Slate notices this in warmer months,

“In the warming summers, some [areas] stay around 80 or 90 degrees; it bleaches the corals. It is too hot because at low tide some of the corals are inches underwater. Some even stick up. That heat is cyclical.” (2018).

It makes sense that the temperature of the water at shallow depths is the hottest because there are fewer particles in the water to disrupt sunlight. So at low tide, when the water level retreats, these corals that were already shallow may only be inches beneath the surface if at all. Without the cooling component of the ocean water, corals that are very near the surface or poking up above the surface will begin to bleach because not only has the temperature of their environment increased but also through the new undisrupted proximity to the sun’s rays. Corals are already a considerably sensitive species, but once combined with more than one stressor, they bleach as they struggle to survive in the new condition.

Tropical Storms

“The other enemy of the reef is storms” (Slate, 2018).

Another concern for local community members in the Florida Keys is storm damage. Spenser Slate describes the effects from a recent incident, “We just had one [tropical storm], Hurricane Irma, and shallow reefs within 20 feet or closer range got turned up by the 20-30ft waves we had” (2018). Corals were destroyed, species were displaced, and increased turbidity accounted for some of the aftermath from the storm. Buchman describes one scene, “We saw impacts [of Hurricane Irma] all over, particularly in brain corals; there were brain corals three feet in diameter that tumbled around like they were mushroom caps” (2018). The power of the storm

was unmerciful to the corals and the reefs took a massive toll. In an attempt to minimize some of the damage to the reef, restoration efforts have been conducted for the corals through nurseries and outplanting. Another challenge with overturned waters in the event of a storm is dramatically increased turbidity. Buchman describes how an increase of particles in the water can be an additional stressor,

“The corals are symbiosis with algae in their tissues, depending on what species they can gain up to 90% of their food from these algae that are in their tissues. So when there’s turbidity, there is not as much sun for these algae to grow. The turbidity is also a fine silt that clogs their feeding mechanisms” (2018).

Storms add to the existing stressors on a reef, but it is not only the efforts of the community that have been responsible for coral restoration; coral has an incredible ability to regrow on its own. Slate confirms, “Coral upturned in a storm, regenerates and starts to grow piece by piece if the water quality is healthy” (2018). While there are factors such as temperature or pollution to consider for determining the quality of water, coral does have the ability to regenerate on its own should conditions be favorable. Temperature may seem out of the question with global warming in effect, but Buchman describes an alternative viewpoint, “Looking at hurricanes and bleaching, there is a positive effect with hurricanes; they turn the water up which tends to lower the temperature, and then the following year we don’t see quite as much bleaching stress on the corals” (2018). So, even the corals that are damaged in a storm event have the potential to recover due to the temporarily lower sea temperatures.

The aftermath of these storms demand a focused and lengthy clean up process for trash, runoff, and other forms of pollution. Even a year after Hurricane Irma, Nivens notices, “People are cleaning up their own canals and it's a shame; the government should be helping, should be helping like they promised” (2018). The lack of government assistance in such a massive endeavor is understandably frustrating, but it is the members of local communities that are motivated to reinvest in their environment and salvage its remaining potential.

iii. Restoration

This section includes excerpts from my conversations with Frazier Nivens, Jeff Nelson, and Spenser Slate that share why Florida’s reefs are important and what are some potential actions towards restoring and protecting them from further devastation.

“Coral reefs are the lifeblood of our planet. Without healthy oceans and the fragile marine ecosystems that inhabit them, man is not going to survive” (Nivens, 2018).

Nivens speaks to trueness of the global importance of reefs to sustaining life, but it is the lack of realization from the many that knowingly and unknowingly rely on its resources what is needed to protect it. Buchman speaks on behalf of NOAA when he says, “Our biggest challenge is trying to educate people about the reef, to raise awareness about the reef system and what they [tourists] can do while they’re here not to impact it.” (2018). This national administration still struggles with topics like these even after their establishment more than 200 years ago, which can attest to what a large concern this is. When people are more knowledgeable on environmental concerns, they are more willing to change a behavior or aspect of their lifestyle.

Nelson agrees, “Being aware of how things affect other things is the piece of the link to try and figure out why it [the reef] goes from beautiful to devastating” (2018). The balance and cycle of seeing how actions interact with one another is an additional step in showing people how they can reduce their impact on marine life. He also takes responsibility for this educational need by saying, “It’s up to professionals, and instructors especially, we’re the ambassadors” (Nelson, 2018). If the ones who are introducing people to the ocean show genuine care and concern for the ocean and its habitats, those that follow are more likely to carry a similar care and concern for the ocean as well.

Contributing an active role in reef restoration is not a new environmental movement. Slate has been investing in the healing process of reefs for decades; one way was when the sea urchin population suddenly declined. Sea urchins are an indicator species of the Florida Keys; they are highly sensitive to environmental changes because their presence in a habitat correlates with a homeostatic environment. When Slate was working on a project in the Bahamas, he joined a team focused on restoring the sea urchin population.

“The team would dive the reef and collect all the sea urchins in shore and put them in coolers. Then we would take them out on the site from 80 to 100 feet of the reef and put them out: year after year, in a ten year project, we saw the coral become healthier because of the sea urchins” (Slate, 2018).

This indicator species has been gradually returning, but coral still faces dense challenges, especially hard corals. Nivens speaks to restoration practices on these hard corals,

“Under permit from NOAA, we take a circular ‘leather punch’ and punch holes into the corals and we would measure the regeneration rate of the coral. We’d take three to six core samplings of the coral, punch holes in the coral, and seal them up with putty, and then we’d come back and measure the healing rate of that coral for a rate of time” (2018).

Another process for hard coral restoration is by using a Coral Tree Nursery™. Slate actively witnessed this process back in the 1980s when coral growing in a nursery setting was being used for reef restoration,

“by snapping off the ends of little pieces of coral while it was still there, bringing it inshore and putting them on these aluminum built trees to hang it with a piece of monofilament line. Then growing it and cementing it into a tiny cement block and going out to plant it” (2018).

Since then, he has seen 90% of those corals come back from their efforts (Slate, 2018). Coral Tree nurseries are certainly time consuming, but they take advantage of the corals natural ability to reattach and regrow, which helps maintain the reef after large-scale breakage. These operations of outplanting and a desire to continue informing visitors are two ways that are currently being exercised to restore and protect the reefs in Florida.

Discussion

When first observing the declining reef health in Florida, I had hypothesized that the main contributors to such a dramatic change would be climate change and recreation. Climate change accounted for the biological alterations in the marine environment and recreation accounted for the physical alterations brought on by direct, human contact. A combination of these two factors was what I had expected to be the most responsible for the area's recent declining reef health.

I. Effects: Climate Change

Before interviewing divers and reef experts in Florida, I expected climate change to be mostly related to bleaching incidents. Climate change has been held responsible for many of the drastic incidents of bleaching globally, deteriorating 50% of the Great Barrier Reef already (De'ath, 2012). As warmer global temperatures translate to warmer surface water temperatures, corals are far too sensitive to withstand the new increases. However, I had not considered what other factors were being impacted by climate change simultaneously, such as tropical storm intensity. Though this in itself is a grave negative effect, there is a positive side effect; tropical storms turn up the water and lower ocean temperatures (Buchman, 2018). Even while an increased magnitude, breakage, turbidity are harmful effect on the corals, the cooler water allow some means for the coral to recover.

Similarly, I wondered what other actions were being made to tackle some of these obstacles and was pleasantly surprised to learn about many of the restoration plans functioning effectively in Florida already. The processes in which these organizations monitor, grow, and replant coral is having tremendous results on the reef. The Coral Restoration Foundation is an organization

aimed at this specific approach for Staghorn and Elkhorn corals (2018). Yet, through my interviews I recognized there are many variations of projects like this and much smaller groups are organizing themselves to join this restoration cause. This approach is mostly reactive, but in some areas the corals are proliferating around 90% (Slate, 2018). Actions like these are what can relieve some of the devastation to Florida's reefs.

II. Effects: Recreation

Beyond the stresses on a coral reef from climate change, I expected recreation to be another massive contributor to declining reef health, mostly in the form of tourism. While I had considered a manner of carelessness to be the source, after interviewing divers and reef experts it became more apparent that uneducated tourism was more of a challenge in preserving the reefs. It is not that people are unwilling to be conscientious about their behaviors and how they relate to the ocean; they simply don't know the effect their behaviors are having or what they can do to help. This is heavily due to perspective; to visitors, the reefs are as beautiful and healthy as they have ever been (Buchman, 2018). They do not understand the challenges the reefs are facing because they are unfamiliar with the ecosystems and its needs.

Where I had expected negative consequences of recreation to fall mostly under tourism, there was a mix of benefits also. Though I initially considered how the uninformed, or careless tourist may treat the reef's resources, I had not as heavily considered all of the economic value tourism brings to the communities surrounding the reef that is then reintegrated into the local community. As one would expect, over a million dollars turning five fold in the Florida economy has tremendous benefits to local community members; even if there are more contact points on the

reef (Slate, 2018). This makes a difficult balance between preservation and financial gain, even while long-term preservation also can protect financial security.

Between the lowered temperatures following a storm and revenue benefits through tourism, balance is what perpetuates many behaviors. By choosing to be more environmentally conscientious, informing people about marine life, and providing opportunities for people to serve these ecosystems are certainly places to start. The reefs may no longer have the capacity to be restored to their original glory, but we can protect what remains so it is still available for future generations to use and enjoy (De'ath, 2012).

III. Project

Using the information I gained from my preliminary research and interviews on climate change and recreation, I wanted to develop a medium to display the knowledge and understanding I gained about Florida's reef and communicate it back to the public in order to continue the conversations around reef conservation. To do this, I used Geographic Information System Mapping Technology (GIS) Storyboard, to create a collection of maps, images, and informational text that summarize the content contained in this written project. To communicate my climate change and recreation focuses, I first graphed the respective units of measure. For recreation, I screenshot maps of the national OHI for each year between 2012 and 2017 in a time sequence, so a user can visualize more clearly the years where the score did not fluctuate and years when it notably decreased. Similarly, for climate change, I included a climate map from the National Oceanic and Atmospheric Administration that clearly articulates topics of Average Temperature, Ocean Heat, and Global Average Sea Level and the relationship between them. I

then aligned direct quotes from my interviews that spoke well toward topics related to the broader category of recreation for quick reference. Finally, I included additional links (e.g. documentaries, short clips) and locations (e.g. restoration or marine focused facilities) that I traveled to or used as supplemental material in my own learning in the duration of this project to provide more resources to learn and reach out should a reader be interested.

Conclusion

This project allowed me to observe what has caused the degradation of coral reefs on the Florida coastline and into the Florida Keys since 2012. My two estimations for this change were in the realms of recreation (e.g. tourism) and environmental factors (e.g. climate change), where I uncovered sub-topics of stewardship, economy, tropical storms, ocean warming, and restoration, all that reinforced the complexity of this issue. Recreation in this context referred to many of the human activities that are inhibiting or disrupting natural habitats or animal behaviors, while environmental favors in this context referred to the increased temperatures of the ocean water that is causing coral sensitivity to reach its threshold capacity. By investing more in the knowledge and practices of restoration and protection for this massive ecosystem, it can continue to survive and support the many facets of marine life. Coral reefs are the lifeblood of not only Florida, but of many global environments; they need communities of active participants in education, protection, and restoration to keep them from disappearing forever.

Appendices

Appendix A: References

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Appendix B: Subject Recruitment

Means of Recruitment

Potential participants will be identified through means of networking, research, and their positions held or relevant experience; they will be individuals 18 or older that have at least five years of experience with water-related topics, such as water quality, coral reefs, or oceans.

Inclusion/Exclusion Criteria

Inclusion: Individuals 18 or older and have at least five years of experience with water-related topics such as water quality, coral reefs, or oceans. Exclusion: Individuals younger than 18 or individuals that do not have at least five years of experience with water-related topics, such as water quality, coral reefs, or oceans.

Phone Script

Good day, my name is Kami Kleefisch and I am an undergraduate student at Ball State University. I gained your contact information through [such means] and am interested in sharing a conversation with you about reef health on the Florida coastline. If you would be willing, please contact me back at [contact info here] so we can be in touch.

Email Script

Good day,

My name is Kami Kleefisch and I am an undergraduate student at Ball State University in Indiana. I gained your contact information through [such means] and am interested in sharing a conversation with you about reef health on the Florida coastline.

For my thesis, I am studying indicators of Ocean Health Index (OHI) fluctuation such as recreation and climate change, and found your experience in [insert experience or position here] to be an excellent opportunity for me to learn more about my topic.

From March 4 through March 8, I will be conducting in person interviews to be used as a component in a visual display to communicate my findings related to reef health in a user-friendly interface

If you would be interested in sharing a conversation and being a participant in a March interview or you know someone who may be, please contact me at [contact info here] at your convenience.

Appendix C: Interview Questions

Methodology

Interviews will include persons who live or work along the Florida coast and who have knowledge or expertise of coral reef issues (i.e., divers, community members, leaders of ocean conservancies and environmental groups, etc.) to grasp a greater understanding of Florida's reef health over the last five years. Interviews will range from 20-30 minutes and will align with the following core ideas: perception of reef health, coral reef contributions to community, local attitude towards the reefs, where information is being obtained regarding coral reefs, and potential improvement recommendations.

Purpose

Acquiring a grasp of local perspectives will provide a greater sense of community attitudes and assumptions of local reef health on the Florida coastline.

Introductory Details

- Participant's name
- Positions past and current
- Duration of positions held
- Place of employment

Questions

1. How would you describe the reef health in your community?
2. How do you see coral reef contributing to the local economy?
3. How do you see coral reef contributing to a larger economy (state, national, global)?
4. Have you noticed any changes in your community or the state that have affected the health of coral reefs over the last five years?
5. How does the community seem to perceive the importance of protecting the surrounding reefs?
6. Has this changed over time? If so, how?
7. Where is information on coral reefs being obtained and shared for this area?
8. How is it being shared?
9. What practices would you recommend to corporations to improve the health of the reefs?
10. What practices would you recommend to individuals to improve the health of the reefs?

*** Is there anyone you would recommend I should talk to or that you would be willing to pass my information along to?

Supplements

Kleefisch, K. C. (2018). Florida's Reef Health. Retrieved from <https://arcg.is/1HTuiD>

IRB Form

From: Sandra Currie <no-reply@irbnet.org>
Sent: Friday, February 23, 2018 13:56
To: Kleefisch, Kami Christina
Subject: IRBNet Board Action

Please note that Ball State University IRB has taken the following action on IRBNet:

Project Title: [1185482-1] Florida Reef Health from 2012 to 2017: Major Indicators of Ocean Index Fluctuation
Principal Investigator: Kami Kleefisch

Submission Type: New Project
Date Submitted: February 22, 2018

Action: RESEARCH - NOT HSR
Effective Date: February 23, 2018
Review Type: Administrative Review

From: Sandra Currie <no-reply@irbnet.org>
Sent: Friday, February 23, 2018 13:55
To: Kleefisch, Kami Christina
Subject: IRBNet Board Action

Please note that Ball State University IRB has taken the following action on IRBNet:

Project Title: [1185482-1] Florida Reef Health from 2012 to 2017: Major Indicators of Ocean Index Fluctuation
Principal Investigator: Kami Kleefisch

Submission Type: New Project
Date Submitted: February 22, 2018

Action: APPROVED
Effective Date: February 23, 2018
Review Type: Exempt Review

Should you have any questions you may contact Sandra Currie at slcurrie@bsu.edu.



Completion Date 20-Feb-2018
Expiration Date 19-Feb-2021
Record ID 25863364

This is to certify that:

Kami Kleefisch

Has completed the following Citi Program course:

Social & Behavioral Research - Basic/Refresher (Curriculum Group)
Social & Behavioral Research - Basic/Refresher (Course Learner Group)
1 - Basic Course (Stage)

Under requirements set by:

Ball State University

CITI
Collaborative Institutional Training Initiative

Verify at www.citiprogram.org/verify/?w4d232c92-a0dc-4772-87dc-9ebc6b611e60-25863364